The Use of Multiple Acoustic Technologies to Characterize The Spatial and Temporal Dynamics of Nassau Grouper (*Epinephelus striatus*) at a Spawning Aggregation in Puerto Rico

El Uso de las Tecnologías Acústicas Múltiples para Caracterizar el Espaciales y Temporales Dinámica del Mero de Nassau (*Epinephelus striatus*) en una Agregación Reproductiva en Puerto Rico

L'utilisation de Plusieurs Technologies Acoustiques pour Caractériser la Dynamique Spatiale et Temporelle de Mérou Rayé (*Epinephelus striatus*) à une Agrégation de Frai à Puerto Rico

EVAN TUOHY*, MICHELLE SCHÄRER-UMPIERRE, KIMBERLY CLOUSE,
MICHAEL NEMETH, and RICHARD APPELDOORN
*Department of Marine Sciences, University of Puerto Rico, Mayaguez, Puerto Rico 00680-9000 *evan.tuohy@upr.edu.*

ABSTRACT

The Nassau grouper, *Epinephelus striatus*, were once considered the most commercially important grouper species in the Caribbean. However, decades of overexploitation has led to their virtual disappearance within the coastal waters of Puerto Rico, despite being fully protected since 1990. The only known Nassau grouper spawning aggregation in Puerto Rico occurs at Bajo de Sico, an isolated seamount located within the Mona Passage. During the 2013 and 2014 spawning seasons, 29 Nassau grouper were surgically implanted with acoustic tags *in situ* using closed-circuit rebreathers. Simultaneous data were collected at the aggregation site using passive acoustic recorders and underwater visual census to compare temporal patterns and estimate population size. Results for this location indicated three peaks in abundances of Nassau grouper occurring shortly after the full moons during the months of January - March, with the duration and timing of peak abundances varying between months. The majority of tagged individuals (24 of 29) were detected at the aggregation site during multiple peaks through the spawning season. Tagged fish displayed greater variability in the day of arrival than timing of departure, but patterns in the time of day of arrival and departure were predictable. Results from passive acoustic recordings and underwater visual censes coincided with tag detection data, with the maximum number of courtship associated calls (CAS), number of individuals observed, and tag detections occurring on similar days.

KEYWORDS: Nassau grouper, spawning aggregation, tagging, passive acoustics

INTRODUCTION

Nassau grouper have long been an icon of the Caribbean, known for the formation of remarkable spawning aggregations consisting of thousands to tens of thousands individuals (Sadovy de Mitcheson et al. 2008). However, more recently they have become better known for the collapse of spawning aggregations due to overfishing by commercial and recreational fishers. Nassau grouper are currently listed as Endangered by the International Union for the Conservancy of Nature (IUCN), after a reported 60% decline in population that has occurred within the last 30 years. Puerto Rico has been no exception to this trend (Ojeda et al. 2007), where they are considered commercially extinct with only one known spawning aggregation remaining within the waters of Puerto Rico.

This research outlines a proportion of the work conducted for the Nassau Grouper Spawning Aggregation Monitoring Project, a multi-year project funded by the Caribbean Coral Reef Institute (CCRI) and the Caribbean Fisheries Management Council (CFMC). The specific objective of this research was to characterize the spatial and temporal dynamics of Nassau grouper at a spawning aggregation via passive acoustic monitoring and acoustic telemetry. Furthermore, the results of these analyses were compared with observed counts of Nassau grouper obtained during diver-based underwater visual census (UVC) completed at the aggregation site during peak spawning periods.

METHODS

This research was conducted on the only known spawning aggregation of Nassau grouper in Puerto Rico. The aggregation takes place at Bajo de Sico, a remote seamount within the Mona Passage located 27 km off the west coast of the island. Passive acoustic monitoring was conducted using digital spectrogram (DSG) passive acoustic recorders (Loggerhead Instruments) that were deployed at the study site from December to June to monitor the courtship associated sounds (CAS) produced by grouper species during spawning (Schärer et al. 2013). These devices were programmed to record at intervals of 20 seconds every 5 minutes for the entire duration of deployment. In addition, 29 Nassau grouper were surgically implanted with acoustic transmitters (VEMCO; V16-4H and V16-4Hp) *in situ* using closed-circuit rebreathers at depths between 40 - 50m. Approximately 10% of Bajo de Sico shallower than 100 m, is monitored for the presence of tagged individuals with an array of 15 omnidirectional acoustic receivers (VR2 and VR2W) deployed year round at the study site. Receivers were deployed at depths of 40 - 75 m in the areas where Nassau grouper are known to aggregate, in addition to areas suspected to function as migration corridors. The spatial and temporal dynamics of peak spawning activity throughout the aggregation season were quantified and compared by analyzing daily CAS and daily tag detections frequencies at the aggregation site, and compared to maximum daily counts of Nassau grouper.

RESULTS AND DISCUSSION

Results indicated a tri-modal distribution in abundances of Nassau grouper occurring shortly after the full moons for the months of January - March of 2014 (Figure 1), with the duration and timing of peak abundances varying between months (Table 1). The January and February modes shared similar characteristics in terms of timing, duration, area and shape of the curve (Figure 1, Table 1). The final mode, corresponding to the March full moon, differed slightly from the previous months, with the absence of a robust peak (Figure 1) and greater temporal variability in the range and timing of peak activity (Table 1). ‘

The simultaneous use of passive acoustic monitoring, acoustic telemetry and UVC to monitor this spawning aggregation proved highly effective. Although both acoustic monitoring techniques record different metrics, both reported similar results and indicate the timing of peak activity and abundances at the aggregation site. Comparison with UVCs showed high congruency among the survey methodologies, where increased numbers of observed individuals within each mode corresponded to increased CAS and tag detection frequencies. The use of acoustic technologies to monitor this spawning aggregation proved highly advantageous, as they allow for continuous monitoring even when environmental conditions do not permit diver-based UVC.

The presence of a similar tri-modal distribution was not observed in the previous year at the aggregation site (Schärer et al. 2014). Yearly variability in aggregation dynamics emphasizes the need for long-term monitoring, especially when population densities are levels of magnitude lower than historically reported. Incorporation of continuous monitoring techniques ensures that the most accurate information is being incorporated so that management actions deliver the highest degree of protection, ultimately safeguarding spawning stocks, while justifying management actions to all stakeholders.

Table 1. Range in days and day of peak sound production of Nassau grouper recorded at the aggregation site. The range, mean ± SD and peak day of detections for acoustic tags detected at the main aggregation site. Days are reported as days after full moon (DAFM).

	Range	Mean ± SD	Peak Activity
CAS			
Peak 1	11	----	12
Peak 2	13	----	14
Peak 3	10	----	11
Tag detections			
Peak 1	10-15	12.2 ± 1.9	12-13
Peak 2	10-14	11.9 ± 1.3	14-15
Peak 3	6-10	8.5 ± 0.9	6-10

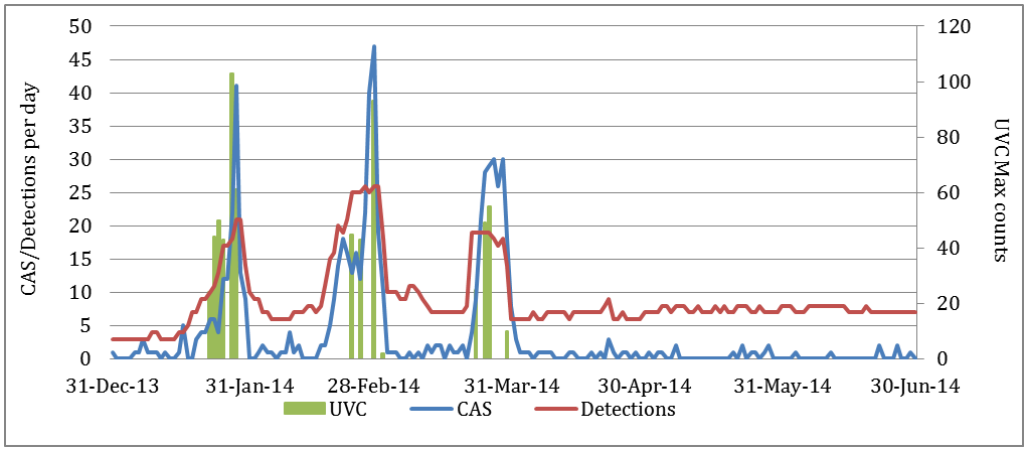

Figure 1. Daily courtship associated sounds (CAS) recorded by passive acoustic recorders and daily acoustic tag detection frequency at the aggregation site.

LITERATURE CITED

Sadovy de Mitcheson, Y., A. Cornish, M. Domeier, P.L. Colin, M. Russell, and K.C. Lindeman. 2008. A global baseline for spawning aggregations of reef fishes. *Conservation Biology* **22**(5):1233-1244.

Ojeda-Serrano, E., R.S. Appeldoorn, and I. Ruiz-Valentín. 2007. Reef fish spawning aggregations of the Puerto Rican Shelf. *Proceedings of the Gulf and Caribbean Fisheries Institute* **59**:467-473.

Schärer, M.T., T.J. Rowell, M.I. Nemeth, and R.S. Appeldoorn. 2013. The courtship associated sounds of Nassau Grouper, *Epinephelus striatus* (Pisces: Epinephelidae) during spawning aggregations. *Proceedings Gulf and Caribbean Fisheries Institute* **65**:302-304.

Schärer, M.T., R. Nemeth, E. Tuohy, K. Clouse, and R.S. Appeldoorn. 2014. Nassau grouper *Epinephelus striatus* fish spawning aggregations in the US Caribbean. *Proceedings Gulf and Caribbean Fisheries Institute* **66**:408-412.